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ABSTRACT

This study investigated the effects of three types of diagnostic-prescriptive learning assistance, aptitude, and locus of control on the cognitive and affective biology achievement of high school students. The study also determined whether the effects of treatment (diagnostic-prescriptive teaching) were consistent across levels of student aptitude and locus of control. A sample of 93 students enrolled in three Biological Sciences Curriculum Study (BSCS) biology classes was selected. All subjects were stratified on measures of aptitude (high, middle and low) and locus All subjects were stratified on measures of aptitude (high, middle and low) and locus of control (internal and external). Data were analyzed through analysis of variance, analysis of covariance, and selected multiple comparison procedures. Results revealed that the effects of aptitude and locus of control were nonsignificant and the teacher-managed diagnostic-prescriptive treatment group scored higher on cognitive measures. (HM)

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THE EFFECTS OF A DIAGNOSTIC-PRESCRIPTIVE TEACHING STRATEGY ON THE ACHIEVEMENT AND ATTITUDES OF HIGH SCHOOL BIOLOGY STUDENTS

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THE EFFECTS OF A DIAGNOSTIC-PRESCRIPTIVE TEACHING STRATEGY ON THE ACHIEVEMENT AND ATTITUDES OF HIGH SCHOOL BIOLOGY STUDENTS

In order to provide instruction based on individual need, it is proposed (Bloom, Hastings, and Madaus, 1971) that teachers employ methods to determine the entry level capabilities of pupils before instruction begins and to monitor pupil progress as instruction proceeds. It is, likewise, proposed that teachers then prescribe "instructional cures" based on the needs identified from diagnosis of the individual learner.

Diagnosis is defined here as any method of determining a pupil's status with regard to both instructional readiness and progress. Prescription is defined here as any course of action recommended by teachers on the basis of diagnosis. The strategy of using diagnosis and prescription, whether administered to individuals or groups, is logically referred to as diagnostic-prescriptive teaching.

Management is a major obstacle in providing diagnostic-prescriptive learning assistance. It is an ambitious task for teachers with large numbers of students to provide for individual needs. Preparing pupil entry profiles, writing instructional objectives and test items, administering two or three diagnostic tests weekly, scoring the diagnostic tests, interpreting the test results, grouping as necessary, and prescribing instruction based on individual performance for several students would tend to discourage all but the most dedicated of teachers. What then are the alternatives for management of a diagnostic-prescriptive teaching strategy?

The practical alternatives are a teacher-managed system or a system developed by teachers to be accessible to and managed by participating learners. The more complex and varied the learning needs within a classroom, the more complex and varied the support system for learning assistance must be. The

support system for assistance must be carefully designed to ensure maximum participation if it is to be student-managed.

Pupil characteristics such as age, prior academic success, locus of control perceptions, and academic aptitude are but a few of many personalogical variables to be considered in the development and administration of a student-managed system. This is not meant to imply that a teacher-managed system should be developed without consideration of pupil characteristics. It is apparent, however, that if students are going to be given primary responsibility for the identification of their learning neds and participation in self-remediation, they must possess attributes that predispose them to a willingness and capability of assuming such responsibility. The personalogical variables examined as main effects in this study are academic aptitude and locus of control.

Bloom (1973) proposed that diagnostic-prescriptive learning assistance can reduce the correlation between aptitude and achievement among low ability students. The extent to which students without a history of academic success will participate in identifying and meeting learning needs, however, is less certain. Similarly, some students may express a belief in an external locus of control whereby reinforcement is perceived as the result of luck, chance, fate, or under the control of powerful others. In contrast, many other students may perceive reinforcement as entirely contingent upon their own behavior, effort, or actions (i.e., internal Locus of control). It follows that those students with an internal locus of control orientation would exhibit a greater willingness to accept responsibility in a diagnostic-prescriptive learning environment.

The intent in this study was to provide learner's with differing types of diagnostic-prescriptive learning assistance, determine academic aptitude and locus of control orientation, and examine the effects of these variables

on short-term cognitive achievement and attitudes toward biology content and instruction.

Research Questions

Specific questions addressed in this study included:

1. What are the effects of differing types of diagnostic-prescriptive learning assistance on the biology achievement of students?
2. What are the effects of aptitude on the biology achievement of students?
3. What are the effects of locus of control perception of the biology achievement of students?
4. What are the effects of differing types of diagnostic-prescriptive learning assistance on the attitudes of high school biology students toward subject matter and instruction?
5. Are the effects on achievement of different levels of diagnostic-prescriptive learning assistance consistent across all levels of student aptitude?
6. Are the effects of achievement of differing levels of diagnostic-prescriptive learning assistance consistent across all levels of locus of control?
7. Are the effects on achievement of different levels of diagnostic prescriptive learning assistance consistent among the combined effects of student aptitude and locus of control?

The rationale for the selection of the independent variables in this study (i.e., the type of assistance in diagnostic-prescriptive instruction, academic aptitude, and locus of contro) is based on the following factors.

If students are to profit from diagnosis and prescription, they must be willing participants in the process. A question of fundamental importance to any teacher contemplating using diagnostic-prescriptive teaching becomes

"To what degree can (and should) students take responsibility for their own diagnosis and prescription?"

Methodology

Sample

The accessible experimental sample consisted of all students (N=93) enrolled in three winter quarter (1978) Biological Sciences Curriculum Study (BSCS) biology classes. The students came from a large comprehensive high school that is highly heterogeneous with regard to race, gender, and socio-economic background. The intention was that the experimental sample is representative of the target population, which is considered to be all U.S. high school BSCS biology students.

Design

A 3x3x2 (treatment x aptitude x locus of control) factorial design with all factors fixed was used to analyze the data for differences in group means and significant interactions. Student scores on the School and College Ability Tests were stratified in high, middle, and low aptitude groups. Internal and external locus of control groups were established on the basis of scores on the Rotter (1966) I-E scale.

The research design used here is a modified non-equivalent control group design (Campbell and Stanley, 1966). The design is modified by the use of covariates rather than a pretest. The design is non-equivalent to the extent that pre-experimental sampling equivalence by randomization was not possible. Treatment levels were randomly assigned to three intact classes one week prior to the beginning of treatment.

Treatments

The three levels of treatment are defined and described as follows:

Control Group

This group received lecture and laboratory biology instruction without benefit of diagnostic tests or prescribed remediation.

Teacher-managed d-p assistance

This group received the same lecture and laboratory biology instruction as the control group. In addition, progress checks were administered two or three times each week. On the day after each diagnostic test, students in this group were apprised of their performance. Review activity sheets keyed to erroneous responses were then assigned.

Student-managed d-p assistance

This group received treatment identical to the teacher-managed group with the following exceptions. A key to each progress check and a file system for obtaining review activity sheets were maintained at a central accessible location within the biology classroom. The responsibility of scoring the progress check from a key, obtaining corresponding review materials, and participating in remediation was left to the student.

Instruments

Three classes of measures pertaining to biology achievement were collected. These were (a) measures of pre-treatment biology achievement to be used as covariates, (b) measures of post-treatment biology achievement to be used as dependent variables, and (c) a measure of attitudes toward biology content and instruction. Table 1 provides descriptive data on the instruments used in this study.

The covariate scores were obtained on the three chapter tests immediately preceding treatment, covering an instructional period of approximately five weeks. Scores on the cognitive measures were collected at the completion of each chapter (about every 8 to 10 instructional days) by administering summative tests. The attitude measure was administered on the day immediately following the last day of treatment.

Table 1

A Summary of Descriptive Data for All Instruments
Used to Assess Biology Achievement

Measure	Type of Items	Validity	Reliability*
Pre-treatment Biology Achievement (O_1, O_2, O_3)	Test items referenced to unit objectives. A combination of types of test items (i.e., T-F, multiple choice, short answer essay items)	Content validity by a panel of judges evaluating correspondence of items to objectives	O_1 $\underline{r}_{tt}$ = 0.71 O_2 $\underline{r}_{tt}$ = 0.78 O_3 $\underline{r}_{tt}$ = 0.75
Treatment Biology Achievement (O_4, O_5, O_6)	Test items referenced to unit objectives. A combination of types of test items (i.e., T-F, multiple choice, short answer essay items)	Content validity by a panel of judges evaluating correspondence of items to objectives	O_4 $\underline{r}_{tt}$ = 0.91 O_5 $\underline{r}_{tt}$ = 0.87 O_6 $\underline{r}_{tt}$ = 0.83
Pupil Attitudes Questionnaire (O_7)	Likert scale items with multiple responses, e.g., "Biology is the best science course I've had."	Content validity by a panel asseesing items and factors to be measure	O_7 $\underline{r}_{tt}$ = 0.71

*Reliabilities were determined for the six cognitive measures by a split-half procedure employing odd and even halves of each measure. The KR-21 procedure was used to estimate the reliability of the attitudinal questionnaire.

RESULTS

The group achievement means (adjusted by covariance) for the cognitive and affective measures administered during treatment are summarized in Table 2.

Three-way analysis of covariance (ANCOVA) procedures with treatment, aptitude, and locus of control as main effects variables were employed to determine the probability of real differences among these means.

Table 2

Summarization of the Adjusted Means of the Dependent Variables Across Treatment Levels

Posttest	Number of Items	Control	Teacher-managed d-p	Student-managed d-p
O_4	50	31.43	35.01	34.61
O_5	29	20.83	22.85	22.03
O_6	23	18.48	20.05	18.80
O_7 Content	9	2.07	2.28	2.86
O_7 Instruction	9	2.40	2.39	3.15

Significant treatment effects were detected on all four measures. The effects of aptitude and locus of control, when adjusted for pre-treatment differences, proved to be non-significant. The analysis of covariance results for all dependent measures are presented in Table 3.

Table 3

Analysis of Covariance Results
For All Dependent Measures

Measure	Treatment		Aptitude		Locus of Control	
	F	p	F	p	F	p
O_4	3.37	.039	0.45	.999	0.01	.999
O_5	2.54	.084	0.01	.999	1.40	.238
O_6	2.41	.096	0.61	.999	0.10	.999
O_7 content	2.60	.079	0.46	.999	1.09	.30
O_7 instruction	3.67	.029	0.15	.999	0.49	.999

Significance levels for all hypothesis testing in this study were set *a priori* at 0.10. Similarly, an *a priori* decision was made to employ the Dunnett-t and the Newman-Keuls multiple comparison tests as procedures for *post hoc* analyses if the omnibus F-test for each dependent variable indicated significant differences among the group means.

From the results shown in Table 3, it can be seen that *post hoc* analyses were needed to determine which treatment groups were achieving significantly better than others. The results of these analyses revealed the following:

1. The teacher-managed diagnostic-prescriptive treatment group scored significantly ($p < .10$) higher than a control group on the three cognitive measures.

2. On the last cognitive measure, the teacher-managed diagnostic-prescriptive group scored significantly higher than the student-managed diagnostic-prescriptive group. Differences detected on the first two measures, while statistically nonsignificant, also favored the teacher-managed diagnostic-prescriptive group.

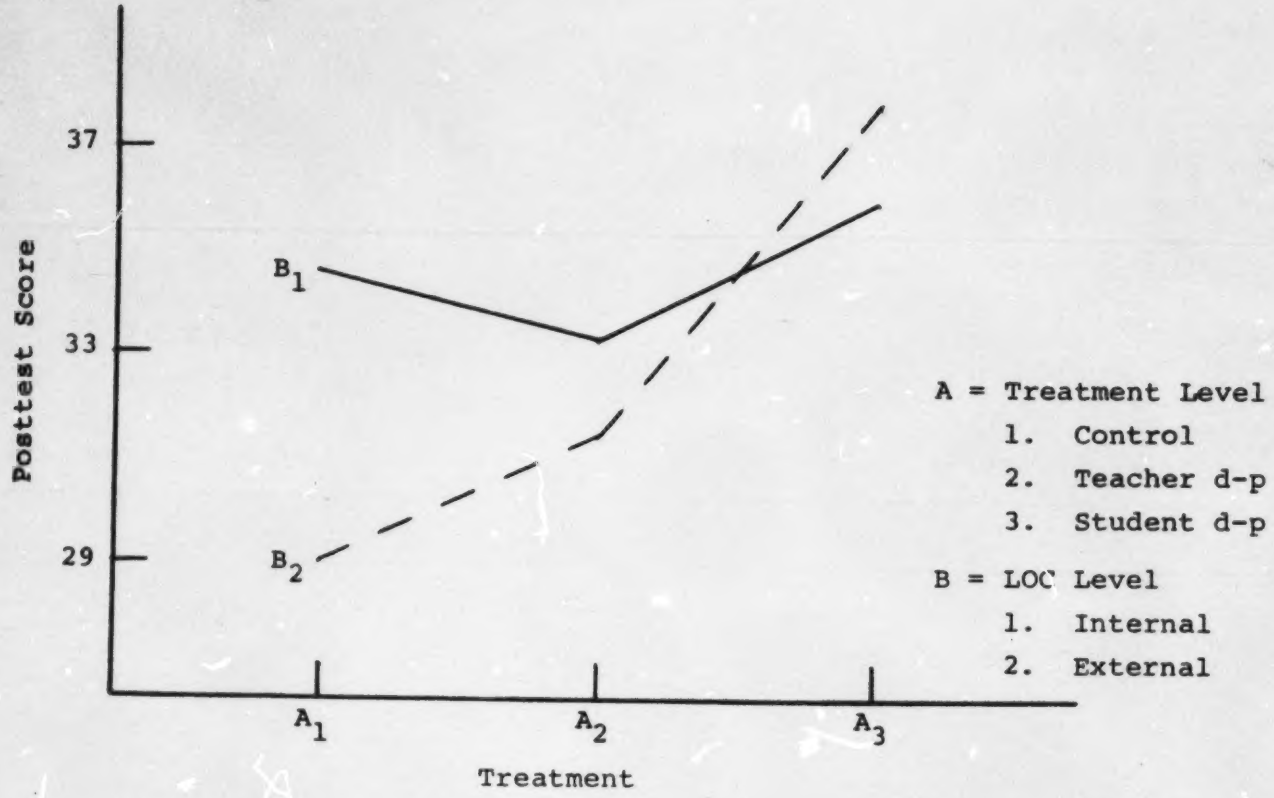

Figure 1. O_4 Posttest, first order interaction--treatment x LOC.

3. The student-managed diagnostic-prescriptive group scored significantly ($p < .10$) higher than all other groups across both attitude dimensions (i.e., content and instruction).

On the first cognitive measure (O_4) a significant ($p = 0.08$) treatment by locus of control interaction was detected. This interaction is illustrated in Figure 1.

This finding is surprising because one could logically argue that among the given levels of treatment, students with an external locus of control would be less likely to capitalize on opportunities to control their academic achievement. The findings reported on this measure were not consistent across other dependent measures.

DISCUSSION

The results here indicate that initially both d-p groups capitalized on the opportunity to monitor their learning progress and to take steps, through remediation, to offset their learning deficiencies. Through time, however, those students managing their own d-p system failed to maintain initial gains in achievement. On the other hand, maximum teacher-intervention in a d-p setting resulted in superior biology achievement through four weeks of instruction. Achievement gains were on the order of 6% to 8%, a finding most encouraging in the face of national declines in science achievement of approximately 2% (Three National Assessments of Science, 1978).

In this study the effects of ability on achievement were not discounted by diagnostic-remedial assistance. Across all levels of treatment, high ability students scored higher than middle ability students who scored higher than low ability students. While the effects of aptitude were not shown to be significant in analyses of covariance procedures applied to posttest scores, it should be noted that the ANCOVA procedures adjusted for

aptitude differences to the degree that they were related to the pre-treatment achievement scores. Aptitude proved to be a significant main effects variable on analysis of variance procedures performed on the unadjusted means of each cognitive measure.

The findings here related to locus of control (LOC) effects as a predictor of academic achievement are inconclusive. There were no significant differences among the adjusted means of internal and external LOC groups on any of the three cognitive measures. The detection of a significant treatment by LOC interaction proves to raise more questions than it answers and subsequently provides direction for further research. It is not unusual for researchers to assume a particular personalogical variable such as aptitude or locus of control has the same effect upon students who differ greatly on other variables. The identification of optimum combinations of instructional method and student aptitude is vital if individual needs are to be met.

The findings here related to attitudes toward biology content and instruction are most encouraging. It is conceivable that an ancillary learning system, regardless of its purpose or inherent value, may be interpreted as just "more school work to be done." This would be especially true in the short run before students had been positively reinforced by increasing achievement. It is concluded here that diagnostic-prescriptive learning assistance did not prove to be injurious to the attitudes of its recipients.

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